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A SIMPLE INSTRUMENT FOR MEASURING SAG IN TELEPHONE LINES

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In regions where there is a large difference between winter and summer temperatures, telephone lines erected during the summer months must be given sufficient sag to prevent them from breaking during the following winter when low temperatures cause the wires to contract. If too much sag is left in a line, wind makes the wires swing, straining the supports and insulators. Excessive sag allows metallic circuits to become shorted by the wires swinging together at transposition points. For any expected temperature range, tables are available giving the proper amount of sag which the wire in a span of any given length should have.

A simple instrument has been devised with which a lineman may measure sag so that the required slack in the line can be introduced when the line is constructed. The body of the instrument is a hardwood strip (Fig. 1) on the ends of which are fastened two brass strips with V-notched bottoms. To measure sag, the instrument is placed near one of the span supports so that the telephone wire fits into the notches of these brass strips. The sliding section S is moved until the arrow point touches the division on the horizontal scale A corresponding to the length of the span in feet. The observer then looks through the pinhole O and through the vertical slit SS, sighting on the insulator on the opposite pole. The sag in inches is read from the vertical scale B at the point where that insulator appears in the slit. The upright scale is hinged so that it may be lowered when not in use.

The theory of the instrument is as follows: a telephone wire hangs so that it forms a curve whose equation is (approximately) the parabola

$$y = ax^2 \qquad (1)$$

where y is the sag and x is one-half the length of the span. Taking the

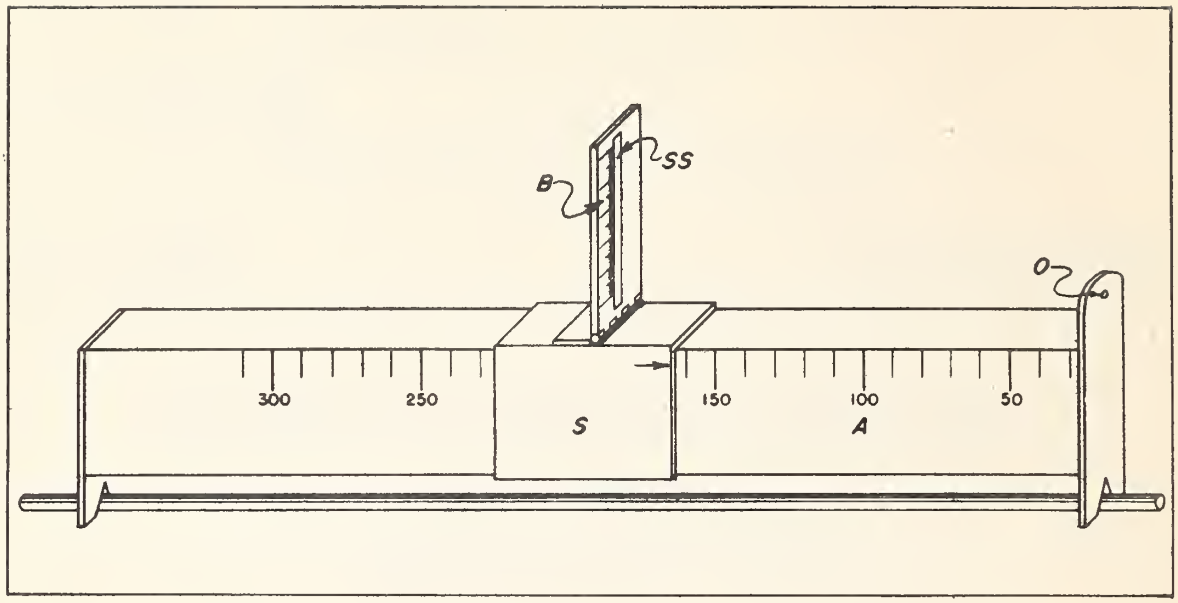

Figure 1.--Diagram of sag-measuring instrument.

first derivative of y with respect to x gives

$$dy/dx = 2ax. \tag{2}$$

Eliminating the constant a between equations (1) and (2) gives

$$y = (x/2)(dy/dx). \tag{3}$$

The instrument measures dy/dx and, since x (one-half of the span length) is known, then y is easily determined. The horizontal scale on the instrument represents dx and the vertical scale dy. The proper units are determined by writing equation (3) in the form

$$dy = (2dx/x)y. \tag{4}$$

If dx is 1 foot when the span is 200 feet (i.e. when x = 100 feet) then

$$dy = 1/50y, \tag{5}$$

so if y is to be in inches then dy should be in fiftieths of an inch (each 1/50 inch representing 1 inch of sag in the wire). The number 200 (representing a span length of 200 feet) is placed 1 foot from the zero end of the horizontal scale; the rest of the span-length scale is then divided into any desired linear intervals of span length such as 10 feet or 25 feet. It will be noticed that each foot of span is equal to 3/50 inch on this scale, hence is 3 times the length of the unit representing 1 inch

of sag on the vertical scale. Different units may be used for different sizes of the instrument, but if the sag is to be measured in inches and the span in feet, the horizontal and vertical units must always bear the ratio of 3 to 1.

A telephone wire actually hangs so that its curve is a catenary, the equation of which is the hyperbolic cosine $y = c \cosh(x/c)$. A chain or cable loaded uniformly per unit length will form a catenary, but if loaded uniformly per unit horizontal distance will form a parabola. Since the two curves are almost identical when the sag is small and are similar even when the sag is fairly large, a negligible error is made in assuming that a telephone wire hangs in a parabolic curve.

An accurate reading cannot be obtained if the tension in the wire is not great enough to straighten out kinks and bends in that part of the wire on and near which the instrument is resting. However, if the lineman sights along the wire, he can detect those bends near the point of support and straighten them out before taking a measurement. There also will be a small error in measurements made on steep slopes if the sag is more than 2 percent of the span length. The error is small if the measurement is made from the higher pole to the lower pole, but if the direction is reversed, the error of measurement may be as great as 15 percent on a 100-percent slope. For instance, if the actual sag is 14 inches, the instrument may show 16 inches of sag if the measurement is made from the lower pole. This error, however, decreases rapidly for less steep slopes and with smaller sag-span ratios. The instrument cannot be used satisfactorily to measure sag in wires near the ends of long cross-arms, too distant from the pole to permit easy sighting with the device.